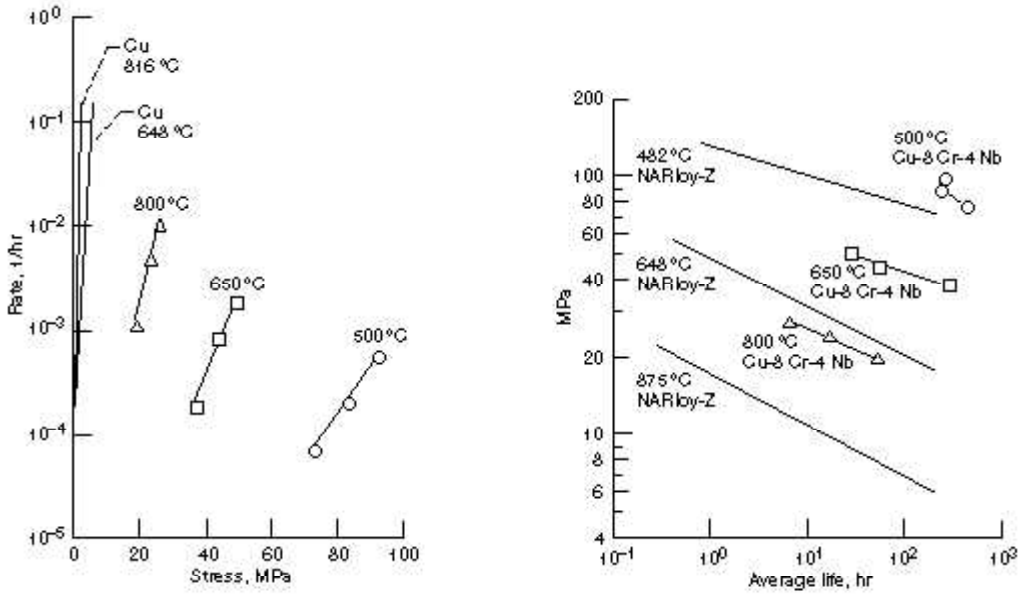
Creep Testing of High-Temperature Cu-8 Cr-4 Nb Alloy Completed

A Cu-8 at.% Cr-4 at.% Nb (Cu-8 Cr-4 Nb) alloy is under development for high-temperature, high-heat-flux applications, such as actively cooled, hypersonic vehicle heat exchangers and rocket engine combustion chambers. Cu-8 Cr-4 Nb offers a superior combination of strength and conductivity. It has also shown exceptional low-cycle fatigue properties. Following preliminary testing (ref. 1) to determine the best processing route, a more detailed testing program was initiated to determine the creep lives and creep rates of Cu-8 Cr-4 Nb alloy specimens produced by extrusion.

Testing was conducted at the NASA Lewis Research Center with constant-load vacuum creep units. Considering expected operating temperatures and mission lives, we developed a test matrix to accurately determine the creep properties of Cu-8 Cr-4 Nb between 500 and 800 °C. Six bars of Cu-8 Cr-4 Nb were extruded. From these bars, 54 creep samples were machined and tested.

The figure on the left shows the steady-state, or second-stage, creep rates for the samples. Comparison data for NARloy-Z (Cu-3 wt % Ag-0.5 wt % Zr), the alloy currently used in combustion chamber liners, were not unavailable. Therefore the steady-state creep rates for Cu at similar temperatures are presented (ref. 2). As expected, in comparison to pure Cu, the creep rates for Cu-8 Cr-4 Nb are much lower. The lives of the samples are presented in the figure on the right. As shown, Cu-8 Cr-4 Nb at 800 °C is comparable to NARloy-Z at 648 °C. At equivalent temperatures, Cu-8 Cr-4 Nb enjoys a 20 to 50 percent advantage in stress for a given life and 1 to 3 orders of magnitude greater life at a given stress. The improved properties allow for design tradeoffs and improvements in new and existing heat exchangers such as the next generation of combustion chamber liners.



Left: Average creep rates for Cu-8 Cr-4 Nb and pure Cu. Right: Average creep lives for

Cu-8 Cr-4 Nb and NARloy-Z.

Currently, two companies are interested in the commercial usage of the Cu-8 Cr-4 Nb alloy. The Rocketdyne Division of Rockwell International is conducting independent testing to analyze the properties for their projected needs in advanced rocket engine applications. Metallamics, a company based in Traverse City, Michigan, is entering into a Space Act Agreement to evaluate and test Cu-Cr-Nb alloys as materials for welding electrodes that are used in robotic welding operations. Creep rate is one of the alloy properties that determines the degree to which a welding electrode will mushroom or expand at the tip. A material with a low creep rate will resist mushrooming and give the electrode a longer life, minimizing downtime. This application holds the potential for large-scale usage of the alloy in the automotive and other industries. Success here would dramatically decrease the cost of the alloy and increase availability for aerospace applications.

References

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